1.3 Land and Soil Quality

Maintaining and improving the quality of the Nation's soils can provide economic benefits in the form of increased productivity, more efficient use of nutrients and pesticides, improvements in water and air quality, and the storage of greenhouse gases. Economic measures of soil quality are needed to monitor and assess the effects of agricultural activities on soil properties. While measures of land capability, productivity, and erodibility are well known, there is an increasing emphasis on soil quality measures that incorporate properties more fully reflecting a soil's potential for long-term agricultural production without negative environmental impacts.

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Maintaining and improving the quality of the Nation's soils can increase farm productivity, minimize use of nutrients and pesticides, improve water and air quality, and help store greenhouse gases. Developing economic measures of soil quality requires a better understanding of the multiple functions of soils and of the interaction between agricultural activities and soil quality. For example, productivity measures reflect the private concerns surrounding soil quality, but other concerns, such as surface-water pollution from runoff, soil productivity for future generations, and the health of agricultural and rural ecosystems, are of broader national interest—and greater economic importance—and need to be reflected in new measures of land and soil quality. Combining the many physical attributes of land and soil quality into meaningful indicators is difficult, as is assigning economic values to these indicators. But only when economic values are generated for these indicators can we fully assess the trade-offs associated with alternative private and public actions.

Traditional Measures of Quality

Soil quality definitions currently follow two concepts (Karlen and others, 1997; Seybold and others, 1997). The first is the "capacity of the soil to function" (Doran and Parkin, 1994). The second is "fitness for use" (Pierce and Larson, 1993; Acton and Gregorich, 1995). "Capacity of the soil to function" refers to the inherent properties of soil formation, which include climate, topography, vegetation, and parent material. These are measured in soil surveys by characteristics such as texture, slope, structure, and soil color (USDA, 1993). "Fitness for use" is a dynamic concept and relates to soils as influenced by human use and management. This concept is often termed soil health or condition. Measures of soil quality such as Land Capability and Prime Farmland are thought to reflect the inherent properties of soil and are based on crop production. Other criteria are needed for other uses of land. The potential capacity of a soil to function must be assessed before a soil's fitness for use can be measured (Mausbach, 1997). Measures of land and soil quality should also account for scale, both spatial and temporal (Halvorson, Smith, and Papendick, 1997). Scale is important

Table 1.3.1—Cropland and soil quality, selected measures, 1992[1]

Measure	Cultivated cropland	CRP	Total	Cultivated cropland	CRP	Total
	1,000 acres			*Percent of acres*		
Land capability class in 1992:						
I (highest land quality)	26,945	214	27,159	7.0	0.6	6.5
II	177,337	7,584	184,921	46.4	22.3	44.4
III	116,687	14,240	130,927	30.5	41.8	31.4
IV and above (lowest quality)	61,349	12,001	73,350	16.1	35.3	17.6
Total	382,317	34,040	416,357	100.0	100.0	100.0
Prime farmland in 1992	215,731	9,688	225,419	56.4	28.5	54.1
Erodibility in 1992:[2]						
Highly erodible from water only	51,924	na	na	13.5	na	na
Highly erodible from wind only	48,933	na	na	13.0	na	na
Highly erodible from both	3,516	na	na	0.9	na	na
Subtotal highly erodible	104,373	19,796	124,169	27.4	58.2	29.8
Not highly erodible	277,944	14,244	292,188	72.3	41.8	70.2
Total	382,317	34,040	416,357	100.0	100.0	100.0

[1] Includes cultivated cropland and land enrolled in the Conservation Reserve Program (CRP) in the contiguous States, Hawaii, and the U.S. Caribbean islands (less than 0.75 million acres).
[2] Highly erodible land has an erodibility index for sheet and rill erosion or for wind erosion greater than or equal to 8.
Source: USDA, ERS, analysis of NRCS 1992 National Resources Inventory data.

because soil quality changes over time and is different by region. Some traditional measures of land quality are discussed in this section.

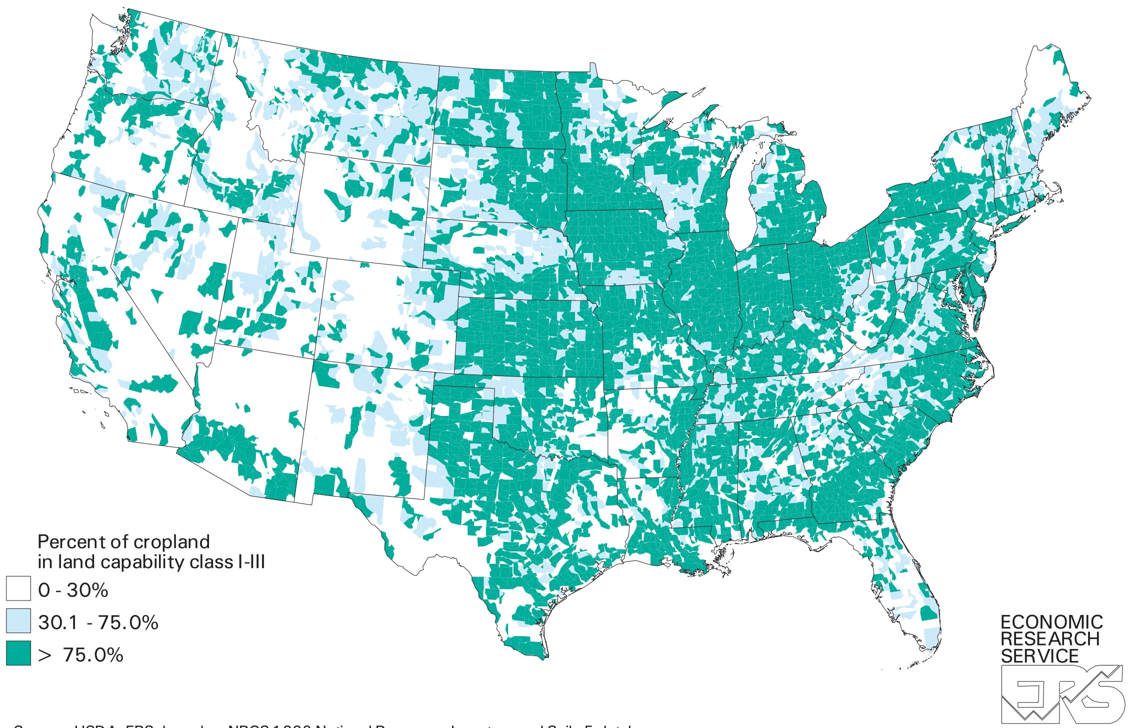
Land Capability and Suitability. Some measures of land quality are used to monitor the capability or suitability of land for a particular purpose, such as growing crops or trees, grazing animals, or nonagricultural uses. Data on two commonly used measures—land capability classes (LCC) and the prime farmland designation—have been collected in the National Resources Inventory (NRI), conducted by USDA's Natural Resources Conservation Service (NRCS) every 5 years (USDA, 1994 and 1989b). (See appendix for a description of the NRI.)

Land capability classes range from I to VIII. Class I, about 7 percent of U.S. cropland, has no significant limitations for raising crops (table 1.3.1). Classes II and III make up just over three-fourths of U.S. cropland and are suited for cultivated crops but have limitations such as poor drainage, limited root zones, climatic restrictions, or erosion potential. Class IV is suitable for crops but only under selected cropping practices. Classes V, VI, and VII are best suited for pasture and range while Class VIII is suited only for wildlife habitat, recreation, and other nonagricultural uses (USDA, 1989a). Land capability classes I-III total 343 million acres, or 82 percent of U.S. cropland including land in the Conservation Reserve Program but excluding Alaska (fig. 1.3.1, table 1.3.1).

Prime Farmland. Another measure of land suitability is USDA prime farmland, which is based on physical and morphological characteristics such as depth of the water table in relation to the root zone, moisture-holding capacity, the degree of salinity, permeability, frequency of flooding, soil temperature, erodibility, and soil acidity. Land classified as prime farmland has the growing season, moisture supply, and soil quality needed to sustain high yields when treated and managed according to modern farming methods (USDA, 1989a). Prime farmland totals 225 million acres, or 54 percent of U.S. cropland, excluding Alaska (fig.1.3.2, table 1.3.1).

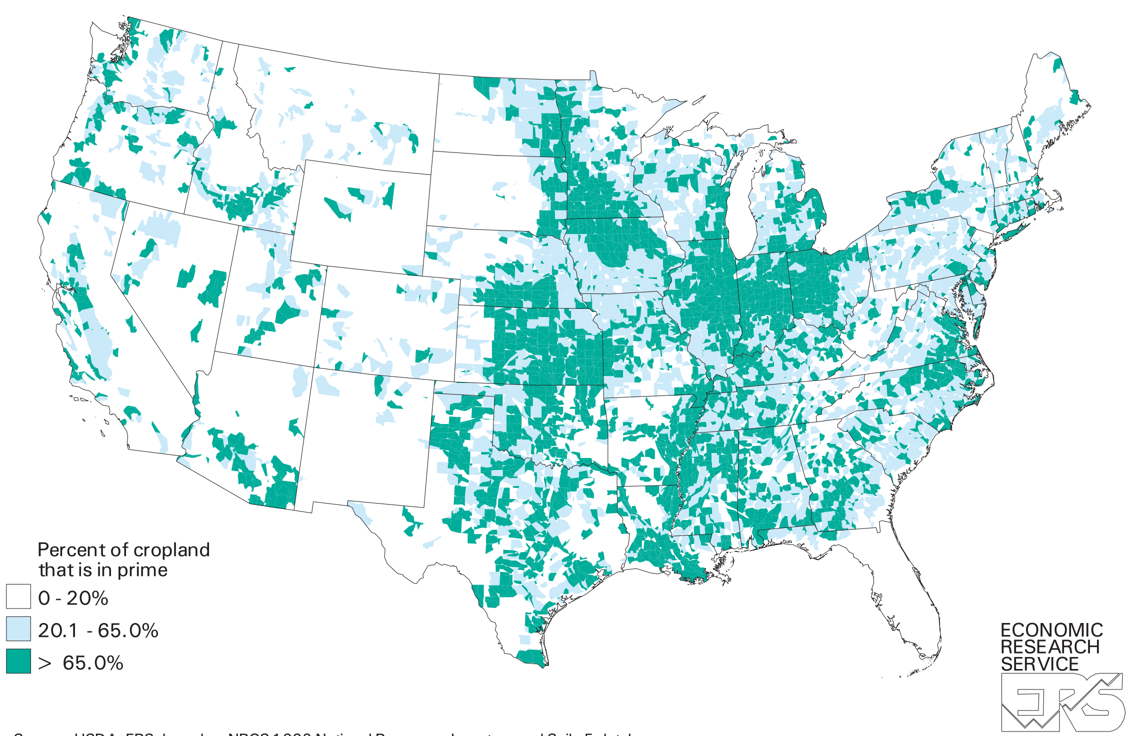
These measures of land quality are often confused with the capability of land to produce economic returns. Land in capability classes I-III or prime farmland does not necessarily have the highest value of crop production per acre (see Vesterby and Krupa, 1993). Alternatively, lands earning high economic returns may not be classified as prime farmland or in LCC I-III. For example, prime and LCC are based on characteristics that reflect suitability for row crop production. Florida and Arizona have little prime

Figure 1.3.1--Distribution of cropland in land capability classes I,II and III on rural nonfederal land



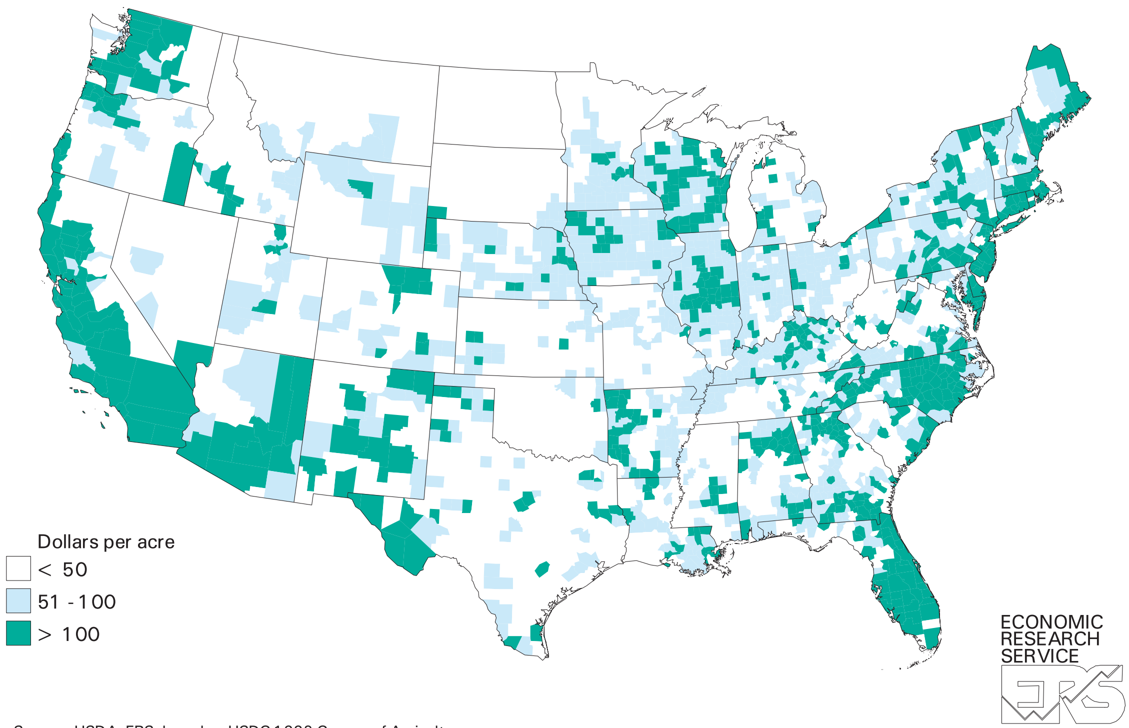
Source: USDA, ERS, based on NRCS 1992 National Resources Invertory and Soils-5 databases.

Figure 1.3.2--Distribution of prime cropland on rural, nonfederal land



Source: USDA, ERS, based on NRCS 1992 National Resources Invertory and Soils-5 databases.

Figure 1.3.3--County average net cash return per acre of cropland



Source: USDA, ERS, based on USDC 1992 Census of Agriculture.

farmland or land in LCC I-III, but these areas rank among the most economically productive in the Nation. (New irrigation will sometimes change a classification from nonprime to prime if other soil characteristics needed for a prime classification are present.)

Productivity. Soil productivity, which measures output per unit of input, is often the primary reason for monitoring soil erosion (or other degradation processes) and is itself a measure of soil quality. Productivity is often measured as crop yield per acre. Another indicator of land quality is the expected net returns per acre from production (dollar returns to production net of cash production costs). Highest values are in coastal areas where climate, soil, location, and irrigated conditions favor production of perishable crops (fruits and vegetables), or where integrated livestock operations draw from an extended cropping area (fig. 1.3.3). The next most productive lands are in the Corn Belt, Lake States, the Northeast, and Southern Coastal Plain. The least productive lands, by this net returns measure, are in bands across the Northern Plains and Central Plains. Productivity can reflect soil degradation if yields decline as soils become degraded or if input use increases to compensate for declines in soil quality. However, productivity often masks environmental or health components of soil quality; lands of poor physical quality (as measured by erosion, texture, organic matter) can sometimes produce very high yields without large increases in input use (Vesterby and Krupa, 1993).

Erodibility. A commonly used measure of soil quality is highly erodible land (HEL), which is of particular importance for USDA conservation policy (see chapter 6). Because the actual tons of wind- and water-eroded soil do not usefully measure the erosion potential on particular soils, USDA uses the erodibility index (EI) to inventory and classify erosion potential and to determine conservation program eligibility. Highly erodible soils have the potential for erosion because of relatively unchanging physical attributes. Associated with sheet and rill erosion are rainfall pattern, soil texture, and topography; associated with wind erosion are climatic and soil erodibility factors. Erosion rates can be reduced if hay or close-grown crops are grown, if tillage methods are used with appropriate crop residue management, and if conservation practices are employed. An assessment of erosion needs to consider both the physical potential for erosion and the erosion rates resulting from management choices.